

## SECTION 419 — SUBFOUNDATION INVESTIGATION

**419.01 DESCRIPTION.** This work shall consist of drilling test holes in rock or other foundation material as a means of verifying the character and suitability of material for foundation purposes.

**419.02 MATERIALS.** Not applicable.

**419.03 CONSTRUCTION.** Test holes shall be drilled in conformance with T 206 and T 225, and shall be drilled at least 10 working days prior to excavation or pile driving in that area. The Contractor shall notify the Engineer at least 10 working days prior to drilling. The locations and minimum depth of the test holes shall be as specified in the Contract Documents or as directed by the Engineer. The Contractor shall record all information on the Administration's boring log Form No. SHA 73.0-46 that is available from the Office of Materials and Technology. The Contractor shall supply a geologist approved by the Engineer or a geotechnical engineer that is a professional engineer registered in the State of Maryland to ensure that the test holes conform to these Specifications.

The geologist/geotechnical engineer shall submit the drilling results to the Engineer within two working days after drilling any given hole or as specified in the Contract Documents. Within five working days after receipt, the Engineer will evaluate the subfoundation investigation to determine if any change in the as-planned excavation is necessary. Foundation excavation will not be permitted until the Contractor receives the Engineer's evaluation for that particular foundation.

**419.04 MEASUREMENT AND PAYMENT.** Subfoundation Investigation will be measured and paid for at the Contract unit price per linear foot for the actual total length of holes drilled. The payment will be full compensation for the geologist or geotechnical engineer services, and for all material, labor, equipment, tools, and incidentals necessary to complete the work.

## SECTION 420 — PORTLAND CEMENT CONCRETE STRUCTURES

**420.01 DESCRIPTION.** This work shall consist of constructing concrete structures or portions of structures including the furnishing, transporting, mixing, placing, curing, and finishing of the portland cement

concrete and protecting the structures as specified in the Contract Documents or as directed by the Engineer.

## 420.02 MATERIALS.

Curing Materials	902.07
Form Release Compound	902.08
Concrete Mixes	902.10 and 420.02.04
Grout	902.11
Linseed Oil	902.12
Drains, Downspouts, Weep holes and Pipes	905
Reinforcement	908.01
Cast Iron Scuppers	909.04
Anchor Bolts	909.06
Steel Forms Which Remain In Place	909.11
Joint Sealer	911.01
Preformed Joint Fillers	911.02
Preformed Elastomeric Joint Seals	911.04
Water Stops and Flashing	911.08 and 913.05
Production Plants	915
Fusion Bonded Epoxy	917.02
Water	921.01
Epoxy Bonding Compound	921.04

**420.02.01 Admixtures.** Calcium chloride or any other admixtures containing chloride salts shall not be used in the concrete placed on steel bridge deck forms which remain in place.

**420.02.02 Requirements for Accessories.** All accessories such as inserts and ties that will remain in completed superstructures within the top 5 in. of final deck slab concrete shall be either epoxy coated or made of material other than aluminum that will not rust. All accessories that will remain in parapets, sidewalks or any other portion of the structure designated to have epoxy coated reinforcement steel shall also conform to these requirements. Inserts are prohibited in the top half of slabs exposed to vehicular traffic unless specified in the Contract Documents.

**420.02.03 Precast Reinforced Concrete Box Sections.** Precast reinforced concrete box sections for culverts shall conform to M 259 or M 273 including concrete design strength. All details shall be as specified in the Contract Documents. Construction joints between the walls and the bottom and top slabs will be optional.

**Certification.** Refer to 305.03.06.

**420.02.04 Composition of Concrete Mixes for Slip Form.** If the slip form method is used for constructing concrete parapets and concrete median barriers on bridges, the concrete shall conform to Mix No. 6 except that the slump shall be 1 in. maximum. The slump shall be measured at the placement point as the concrete is being charged into the slip form machine. The coarse aggregate shall be crushed stone conforming to M 43, size number 7, and shall not be less than 63 percent of the total aggregate in the mix. Other size coarse aggregate may be used provided the Engineer approves the slip form results.

**420.03 CONSTRUCTION.** Concrete shall be made either at the work site or away from the work site by an approved central mixing plant, or by approved truck mixing as specified in Section 915.

When the Contract Documents specify the removal of portions of existing parapets or end posts, the removal shall be in conformance with 405.03.

**420.03.01 Equipment.** The Contractor shall use equipment of sufficient capacity to complete any unit or section of concrete between construction joints, as specified in the Contract Documents, in one continuous operation consistent with placement operations as approved by the Engineer. Hand mixing may be permitted with written approval of the Engineer for small volumes of concrete. However, its intended use is for small isolated areas where structural integrity is not critical and the volume does not exceed 1 yd<sup>3</sup>.

**420.03.02 Forms.**

**(a) Design Criteria.**

**(1) Design Loads.** Design loads shall conform to AASHTO Standard Specifications for Highway Bridges, Temporary Works, Loads. The lumber in the forms shall be assumed to weigh 50 lb/ft<sup>3</sup>.

**(2) Design Stresses.**

**Timber Design.** Timber design for formwork shall conform to ACI Standard Recommended Practice for Concrete Formwork (ACI 347). Unit stresses stipulated in AASHTO for treated timber may be increased by 25 percent but shall not exceed the values listed below. Deflections for form members shall not exceed 1/270 of the span or 1/4 in.

Compression Perpendicular to Grain	450 psi
Compression Parallel to Grain	1600 psi
Flexural Stress	1800 psi
Horizontal Shear	
Beams up to 6 in. deep	200 psi
Beams over 6 in. deep	150 psi
Axial Tension	1200 psi

**Plywood.** The strength of plywood without backing shall be calculated based on the grain of the face plies running parallel to its span. The plywood shall be installed in this manner.

**Steel Members for Forms.** Steel design for formwork shall conform to AASHTO Standard Specifications for Highway Bridges. For design where no dynamic loading is involved, the AISC Standard Manual of Steel Construction, Allowable Stress Design may be used as the accepted design code.

**Steel Forms Which Remain in Place.** The maximum deflection of steel deck forms that remain in place shall not exceed 1/180 of the span and not in excess of 1/2 in.

For steel deck forms that remain in place, camber shall not be used to compensate for deflection in excess of the above limits. The design spans of the form sheets shall be the clear distance between beam or girder flanges less 2 in.

For steel forms which remain in place, the unit working stress in the steel sheet and supporting members shall not be more than 0.725 of the specified minimum yield strength of the material furnished but not to exceed 36 000 psi. Physical design properties shall be computed in conformance with the American Iron and Steel Institute Specification for Design of Cold Formed Steel Structural Members.

- (b) **Working Drawing Approval.** Detail, form, falsework and centering plans and design loads shall be submitted to the Engineer for approval except as specified otherwise in the Contract Documents. Working drawings for forms shall include all members proposed for use as well as form ties and bracing. Details for form ties shall not be submitted separately but shall be incorporated in the general working drawings submittal. The rate of placing concrete shall be noted on the working drawings. Approval of the working drawings will not relieve the Contractor of responsibility as specified in TC-4.01. The provisions of

430.03.28 also apply when working drawings are submitted for falsework and centering.

- (c) **Forms at Construction Joints and Corners.** Ties or bolts shall be provided 3 to 6 in. from each side of concrete construction joints for tightening the forms against the hardened adjacent concrete prior to placing fresh concrete. At joints where forms have been removed and reconstructed, the form surface shall extend over the concrete already in place; and the forms shall be drawn tightly against the previously placed concrete prior to placing the fresh concrete. Forms shall be filleted at all sharp corners, except when otherwise specified in the Contract Documents and shall be given a bevel or draft in the case of all projections. All exposed corners of concrete shall be chamfered with  $3/4 \times 3/4$  in. milled chamfer strips, except on unexposed footings or where specified in the Contract Documents.
- (d) **Form Scaffolds and Platforms.** Form scaffolds and platforms shall be built along the outside of bridge deck fascias during construction of forms for bridge decks. They shall be designed and constructed as an integral part of the form supports. Separate design calculations shall be furnished with the working drawing submission. Approval of the working drawings will not relieve the Contractor of responsibility as specified in TC-4.01.
- (e) **Forms for Unexposed Surfaces.** All sheathing, studs and bracing shall be of sound material. Studs and wales shall be straight and true and surfaced on two edges to a uniform width. The inside face of the forms shall be of sufficiently smooth construction that the resulting concrete surfaces shall be accurately formed.
- (f) **Forms for Exposed Surfaces.** Unless otherwise specified in the Contract Documents, steel forms which remain in place shall be used between stringers to support the bridge deck concrete, except in panels where a longitudinal deck construction joint is located between stringers. Forms to be used on the structure for widening and rehabilitation shall provide that the exposed finished concrete surfaces shall match the existing structure.
- (1) **Lined Forms for Exposed Surfaces.** Contact surfaces of lined forms for surfaces exposed to weather or view shall be approved composition board, sanded plywood or metal. All studs shall be surfaced two edges to a uniform width and shall be of a grade of lumber that is solid, straight and free of defects that could impair its strength. The backing for form lining shall be constructed using a grade of form lumber that

is solid, straight and free of defects that could impair its strength, but need not be of the quality used for contact forms for unexposed surfaces.

All sheathing for form backing shall be surfaced two sides to a uniform minimum of the thickness of at least the dimension approved on the working drawings. Form sheathing shall be built solidly, securely nailed to studs and placed to prevent any bulging of the lining.

- (2) **Unlined Forms for Exposed Surfaces.** Unlined forms in contact with surfaces exposed to weather or view shall be constructed of five ply sanded plywood of the thickness specified in the Contract Documents. Plywood shall be manufactured especially for concrete formwork using waterproof glue. All studs and wales shall be surfaced two edges to a uniform width.

Full size sheets of plywood shall be used except where smaller pieces cover an entire area. All joints shall be backed solidly to prevent leakage and the edges of abutting sheets shall be nailed to the same stud or blocking with sixpenny nails not more than 8 in. apart. Where rustication occurs, horizontal joints in the plywood shall be constructed behind a rustication strip. Otherwise, horizontal joints shall be placed at the same respective elevations in all portions of the structure. Where vertical rustication occurs, vertical joints in the lining shall be constructed behind a rustication strip. Otherwise, vertical joints shall be kept to a minimum and shall be butted tightly together and sealed with a crack filler specified in the Contract Documents, as the plywood is nailed in place.

**(g) Steel Forms Which Remain in Place.**

- (1) **Installation.** The surface of the steel forms in contact with concrete shall be smooth and free of surface irregularities. Working drawings for steel forms which remain in place shall specify the grade of steel, the physical and sectional properties for all permanent steel bridge deck form sheets and a clear indication of locations where the forms are supported by steel beam flanges subject to tensile stresses.

Form supports shall not be welded to flanges of steel that are not considered weldable or to portions of flanges that are subject to tensile stresses.

Welding and welds shall conform to the provisions of the latest AWS Bridge Welding Code pertaining to fillet welds.

Unless otherwise specified in the Contract Documents, steel forms which remain in place shall be used between stringers to support bridge deck concrete, except in panels where a longitudinal deck construction joint is located between stringers.

- (2) **Procedure Check and Inspection.** The Contractor shall remove at least one section of the forms at a location and time selected by the Engineer from each span of each bridge in the Contract. If the bridge has a longitudinal joint, a form on each side of the joint shall be removed from each span. This should be done as soon after placing the concrete as practical to provide visual evidence that the concrete mix and the Contractor's procedures are obtaining the desired results. An additional section shall be removed if the Engineer determines that there have been any changes in the concrete mix or in the Contractor's procedures warranting additional inspection.

At locations where sections of the forms are removed, the Contractor will not be required to replace the forms, but the adjacent metal forms and supports shall be repaired to present a neat appearance and ensure their satisfactory retention. As soon as the form is removed, the concrete surfaces will be examined for cavities, honeycombing, and other defects. If irregularities are found and the Engineer determines that these irregularities do not justify rejection of the work, the concrete shall be repaired as directed by the Engineer. The concrete shall be given an ordinary surface finish in conformance with 420.03.07(a). If the concrete where the form is removed is unsatisfactory, additional forms, as necessary, shall be removed to inspect and repair the slab. The Contractor's method of construction shall be modified as required to obtain satisfactory concrete in the slab. All unsatisfactory concrete shall be removed and replaced or repaired as directed by the Engineer at no additional cost to the Administration.

The Contractor shall provide all facilities as are reasonably required for the safe and convenient conduct of the Engineer's inspection procedures.

- (h) **Steel Forms Which Do Not Remain in Place.** The surface of the steel forms in contact with the concrete shall be smooth and

free of bolts, bolt heads, nuts, rivet heads, welding seams and surface irregularities. Forms that produce unacceptable concrete surfaces will be rejected and shall not be reused.

- (1) **For Round Columns and Piers.** Steel forms for round columns and piers shall have minimum number of horizontal joints and shall be column height. The minimum thickness of these steel forms shall be 10 gauge.
  - (2) **For Pier Caps and Crash Walls.** Prefabricated girder type steel forms may be used for forming pier caps or crash walls. Each element of these forms, including side, bottom and end shall be in one piece where practical. Splices shall be arranged to provide a symmetrical pattern where forms are spliced.
  - (3) **For Reinforced Concrete Box Culverts and Rigid Frames.** Steel forms or forms constructed of wood or composition wood panel sheathing set in metal frames may be used. The minimum thickness of steel forms for box culverts and rigid frames shall be 10 gauge.
- (i) **Fiber Column Forms.** Fiber column forms shall only be used for round columns, and shall conform to these Specifications. The forms shall produce columns truly round and straight and shall be protected from dampness before concrete is placed. Fiber forms shall not be spliced.
- (j) **Release Agents.** All forms shall be treated with form release compound immediately before placing concrete.
- (k) **Temporary Supports.** Temporary supports used for centering and falsework shall be built on good firm foundations. Unless otherwise provided, they shall be founded to bear upon strata at or below the frost line unless rock is available, or piling shall be driven for support where required. The strength and bracing of the temporary supports shall ensure that the completed structure will have the shape shown on the Contract Documents. The Contractor shall employ jacks or hardwood wedges in connection with the temporary supports in order to take up settlement either before or during placing of concrete. Temporary supports shall be set to give the structural camber specified on the Contract Documents, plus allowance for shrinkage and settlement. If during the construction any weakness, settlement or distortion develops, the work shall be stopped and any masonry affected thereby removed and the temporary structures strengthened



before work is resumed. Centering shall be constructed to permit its gradual, uniform lowering.

- (l) **Defective Forms.** Removal or modification of steel forms which remain in place shall be performed using a device approved by the Engineer. Burning is prohibited.
- (m) **Form Ties.** Only form ties approved by the Engineer shall be used. Ties shall leave no metal closer than 2 in. from the surface. They shall not be fitted with lugs, cones, washers or other devices which act as spreaders within the form or for any purpose that leaves a hole larger than 7/8 in. diameter. When prefabricated steel girder forms are used, tapered ties up to 1-1/2 in. maximum diameter shall be used. Ties shall be clean and free of rust. When ties are removed, the holes shall be pressure grouted with a nonshrink mortar mixed to match the color and texture of the concrete.

Portions of ties to be removed from the concrete shall be coated with a clear lubricant or other approved material to facilitate removal.

Care shall be exercised during removal of form ties to avoid spalling the concrete on the exposed surface. Cutting back from the face of the is prohibited.

- (n) **Form Support Brackets or Devices.** Devices attached to previously placed concrete may be used, provided all parts are acceptable to the Engineer. No metal part of an insert, threader or anchor that remains in place in the concrete shall be within 2-1/2 in. of the surface. The concrete supporting the brackets or other devices shall be cured and shall have attained a minimum compressive strength of 3000 psi before the brackets or other devices are attached. All voids left in the concrete after brackets or other devices have been removed shall be no greater than 2 in. diameter and shall be completely filled with mortar and the surface finished as specified in 420.03.07(a).
- (o) **Form Removal.** For the purpose of determining the time when falsework and forms may be removed, backfill placed, and when loads may be applied to structures, an adequate number of concrete test specimens shall be made in addition to those required to check the quality of the concrete being produced. All forms for concrete work shall be removed and disposed of by the Contractor after formwork requirements have been conformed to, except those that are specified to remain in place.

Methods of form removal likely to cause overstressing of the concrete shall not be used. Forms and their support shall not be removed without the approval of the Engineer. Supports shall be removed in a manner that permits the concrete to uniformly and gradually take the stresses due to its own weight.

- (p) **Year Built Marking.** The year of completion shall be cast into each structure, as determined by the Engineer. Forms or molds for casting the year built numerals in the structure shall be supplied by the Contractor. The year built numerals shall be the size specified in the Contract Documents.

**420.03.03 Anchor Bolt Placement.** Anchor bolt placement shall conform to 430.03.31.

**420.03.04 Concreting.** Before placing concrete, forms shall be cleaned. Struts, stays and braces serving temporarily to hold the forms in correct shape and alignment shall not be buried in the concrete. If faces of completed or proposed excavated footing areas are disturbed prior to concreting, the footings shall be extended at no additional cost to the Administration, to bear on undisturbed faces acceptable to the Engineer.

All concrete except tremie concrete shall be placed in the dry.

- (a) **Foundations.** The Contractor shall be responsible for any reinforcement fabricated prior to approval of foundations. If bearing material varies more than assumed in design, footing may be lowered, raised, deepened, subfoundation placed, piles used or a combination of these methods used to best obtain bearing as directed by the Engineer. If planned footings are changed vertically, reinforcement steel shall be revised as required. Subfoundation concrete for bridges, retaining walls and wing walls of box culverts or rigid frames shall be constructed using plain Concrete Mix No. 1 (no reinforcement). The Concrete Mix No. 1 need not be vibrated, and the usual curing and cold weather requirements may be reduced to three days. Selected backfill using number 57 aggregate may be used for subfoundation for box culvert barrels, headwalls and miscellaneous structures.
- (b) **Concrete Placement.** Concrete shall be placed to avoid segregation of the material and the displacement of the reinforcement. The use of troughs, chutes and pipes for conveying concrete more than 15 ft from the mixer to the forms will be permitted only when acceptable to the Engineer. Open troughs and chutes shall be metal or metal lined. Where segregation occurs due to steep slopes, chutes shall be equipped with baffles.

Where placing operations would involve dropping the concrete more than 5 ft, it shall be deposited through a tube made of sheet metal, canvas or other approved material. Aluminum hoppers or tubes are prohibited. Lower ends shall be kept as close as possible to the newly placed concrete and not more than 3 ft above the concrete. All tubes shall have a minimum diameter of 6 in. unless otherwise directed by the Engineer. After initial set of the concrete, the form shall not be disturbed, and no strain shall be placed on the projecting ends of the reinforcement.

Concrete shall be placed in horizontal layers not more than 12 in. high except as provided herein. When less than the complete area of a layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and vibrated before the preceding layer has taken initial set to prevent injury to the concrete and avoid separation of joints between the layers.

Concrete in columns and walls shall be placed in one continuous operation unless otherwise directed. The concrete shall set at least 12 hours before the caps are placed.

Where walls, piers, columns, struts and posts have horizontal construction joints, succeeding lifts shall not be placed until the lower placement has set for 12 hours.

Prior to subsequent placement, all accumulations of mortar splashed upon the reinforcement shall be cleaned. Care shall be exercised not to injure or break the concrete seal bond near and at the surface of the concrete while cleaning the reinforcement steel.

**(c) Superstructure Placement.**

- (1) Grade Controls for Bridge Deck Slabs.** Bridge deck slabs supported by new stringers shall be placed in conformance with the specified line and grade. The Contractor shall take all necessary precautions, including a check on all new bridge seat elevations as the last order of work before setting stringers. Any adjustments resulting from this check shall be completed before additional work is started. After the structural steel is set, a final check of elevations of all the steel stringers at points corresponding to those specified in the Contract Documents for dead load deflection and finished roadway elevations shall be made. Computations shall be made by the Contractor, reviewed by the Engineer, and controls set at proper elevations to produce finished tops of concrete bridge decks that will be true as to planned line and grade of the roadway surface.

Grade control for bridge deck slab replacements shall conform to 405.03.02.

- (2) **Superstructure Placement Restrictions.** The superstructure shall not be erected until the substructure forms have been sufficiently stripped to determine the character of the concrete in the entire substructure, unless otherwise permitted by the Engineer. In all spans, the concrete bridge deck slabs outside of the stringers shall be cast using plywood forms.

Unless otherwise specified in the Contract Documents, concrete for deck slabs shall be pumped whenever the volume of concrete in the pour exceeds 50 yd<sup>3</sup>.

The Contractor shall place all superstructure concrete in conformance with the following schedule:

SUPERSTRUCTURE CONCRETE PLACEMENT SCHEDULE		
DATES	BEGIN CONCRETE PLACEMENT AFTER	FINISH BURLAP PLACEMENT BEFORE
May 15 - June 15	7:00 PM	11:00 AM
June 16 - Aug. 14	9:00 PM	7:00 AM
Aug. 15 - Sept. 15	7:00 PM	11:00 AM
Sept. 16 - May 14	No time restrictions	

Superstructure concrete shall not be placed or worked in any manner when the temperature in an unshaded location at the placement site is above 80 F. Floodlighting shall be used when existing light is less than 20 average horizontal ft-c over the construction area.

The Contractor shall submit a Situation Plan to the Engineer showing the locations and aiming of floodlights. After reviewing this plan, the Engineer will witness a test of the floodlighting system at the proposed construction area. The Contractor shall run the floodlighting test. The floodlighting system shall be capable of maintaining 20 ft-c without producing a glare on traffic. Floodlighting systems will be approved by the Engineer. When portable generators are used, an emergency backup system shall be available at all times on the job site.

- (3) **Rate of Concreting for Bridge Deck Slabs.** Provisions shall be made by the Contractor to ensure that the placement

rate of concrete is 35 yd<sup>3</sup>/hour minimum. Under special circumstances, the Engineer may give written approval to lower this requirement.

The Contractor shall submit for the Engineer's approval written evidence of an adequate source of concrete, and placing and finishing equipment capable of conforming to the minimum rate of placement of 35 yd<sup>3</sup>/hour per crew while providing the intended quality finish. This evidence shall be submitted at least one week prior to the proposed placement of the bridge deck slab.

Concrete in slab spans shall be placed in one continuous operation and in one layer for each span, unless otherwise directed by the Engineer.

Concrete shall not be mounded on concrete slab forms supported by beams, stringers, or girders. When placing, the concrete shall be distributed to a depth not exceeding the planned slab thickness plus 6 in. before spreading, consolidating and finishing.

The placing sequence shall be in the numerical order specified in the Contract Documents and shall not be modified. A minimum of 40 hours shall lapse between the completion of one placement and the start of the next numbered placement.

- (d) **Box Culverts.** Box culverts shall be constructed by casting in place or using precast reinforced concrete box culvert sections. Whenever a particular method is indicated in the Contract Documents, the Contractor may elect to use the alternate method unless otherwise specified. However, all time constraints such as maintenance of traffic, curing, completion dates, etc., shall be met.

If the Contractor elects to use precast reinforced concrete box sections, at least 15 ft of all box culvert ends and all footings, wing walls, headwalls and toe walls shall be cast in place. Additionally, the precast sections shall terminate a minimum of 1 ft from all footings and toe walls. All lifting devices shall be indicated on the working drawings and all lifting holes shall be filled with nonshrink grout after the precast units are in place. The precast reinforced concrete box sections shall be set tightly together and the joints shall be sealed in conformance with the manufacturer's recommendations.

The bottom slabs of cast in place concrete box culverts shall be placed for their full depth in one mass or layer and permitted to set not less than 12 hours before any additional work is done.

Single cell box culverts spanning in excess of 10 ft and multiple cell box culverts shall not have the top slabs placed until the concrete in the sidewalls has set for a minimum of 12 hours. Construction joints at the top of sidewalls may be omitted in some cases provided the top slabs are placed as follows:

- (1) For single cell box culverts spanning 10 ft or less, the sidewall construction joint may be omitted and the top slab placed on the sidewalls, provided the concrete in the sidewalls is allowed to set for approximately two hours before starting to place the top slab.
  - (2) Regardless of size or number of cells, the Contractor may request in writing to place the top slab on the walls of box culverts in conformance with (1) above. The written proposed plan, including rate and method of placement, and type and size of equipment, shall be submitted to the Engineer for approval. If the Contractor receives initial written approval, the first section of the structure shall serve as a demonstration to confirm that there is no excessive cracking or any other detriment, and that satisfactory results will be obtained. After receiving written final approval, the Contractor may continue placing the remainder of the box culvert. If at any time the Engineer decides that the results are no longer satisfactory, the Contractor shall revert to placing the concrete with the 12 hour delay as specified above at no additional cost to the Administration.
- (e) **Forming Concrete Parapets and Median Barriers on Bridges.** The Contractor may construct concrete parapets and median barriers on bridges by either the slip form method or conventional fixed form method. The slip form method is prohibited on bridges maintaining traffic, or on parapets when railing is specified.

Contractors who elect to use the slip form method shall first demonstrate their ability to produce results acceptable to the Engineer. If a Contractor is unable to demonstrate that ability or fails to maintain acceptable results during production, the slip form operation shall be stopped, the unacceptable work shall be removed and the construction methods shall be modified. If construction modifications do not produce acceptable results, the Contractor shall use the fixed form method. No additional

compensation will be permitted, and no increase will be allowed in any Contract price nor will any revisions be made to the amount of time to complete the Contract as a result of any required removals, modifications or changes in the method of placing parapets or barriers.

The Contractor shall notify the Engineer in writing of the proposed method of constructing the parapets and median barriers prior to beginning superstructure work. If slip forming is to be considered, then the following shall apply:

- (1) The Contractor shall submit to the Engineer evidence of being capable of producing high quality slip formwork. Prior to beginning any slip form construction, the Contractor shall submit a detailed work plan. The plan shall include the type of equipment, materials and procedures to be used, any subcontractors involved in the construction, key personnel who will be performing the work (names, training, experience, etc.), as well as detailed information on how the Contractor proposes to satisfactorily complete the work.
- (2) When possible the work plan shall include reference to at least three other similar projects completed in the State of Maryland or surrounding states using the slip forming method for parapet or median barrier construction. As far as practical, these similar projects shall have been built using the same equipment, personnel, material, and procedures proposed for the project. The Engineer may elect to visit these completed projects to evaluate the acceptability of the finished product.

If the Engineer determines that the Contractor has satisfactorily slip formed parapets or median barriers at the locations submitted in the Contractor's work plan, the requirements of the off bridge test site specified below may be waived and the first 50 ft of slip forming on the bridge will be considered the test section for the structure. This test section shall be completed and approved prior to placing the remaining portions of parapet or bridge median barrier.

- (3) The work plan shall be approved in writing prior to beginning any slip forming operation.

Any proposed revisions or deviations to the approved work plan submitted by the Contractor shall be approved by the Engineer in writing prior to making the change.

If the Contractor does not conform to (2) above, an off bridge test section shall be completed and accepted prior to placing any portion of the parapet or bridge median barrier. The Contractor shall place the appropriate test section of parapet or median barrier using the same equipment, sensor line, support spacing, material, personnel and procedures as described in the work plan. This test section shall match the structure's horizontal curve as much as practical, be a minimum of 50 ft long, and be placed at a location selected by the Contractor near the bridge site.

The off bridge test section shall be placed with vertical irregularities varying upward and downward at least  $\frac{3}{4}$  in. The Contractor shall then prove that the method of slip forming can compensate for this deviation and provide a top of parapet or median barrier that is true to the proposed line and grade and not necessarily parallel to top of bridge deck. This will necessitate that the equipment provide for variations in height of vertical face of parapet where it intersects the top of deck slab.

The sensor line shall be positioned, supported, and spaced in the same manner in the testing operation as will be used on the bridge decks with no stakes, holes, etc., used to support it. Sensor support spacing shall be as recommended by the slip form machine manufacturer and as necessary to maintain the planned line and grade. The rate of slip forming on the test section shall be the same as that proposed for the bridge. Joints shall be saw cut in the test section at the same approximate spacing and in the same manner as proposed for the finished bridge.

The Engineer will evaluate the procedure, material, equipment and appearance of the test section. The Contractor shall take three test cores from the test section at locations directed by the Engineer to determine the concrete quality. Honeycombing, sags, tears or other evidence of poor quality concrete will be cause for rejection of the test section. If the test section is rejected, the Contractor may place additional test sections until approved by the Engineer or may elect to use the fixed form method.

The accepted test section shall remain in place until all parapets or median barriers on the bridges are complete. The slip formed parapets and median barriers on the bridges will be compared to the approved test section to ensure that similar acceptable structures are being achieved on the



bridges. Following completion and acceptance of all bridge parapets and median barriers, the Contractor shall remove and dispose of the off bridge test section.

The entire testing procedure, including removing and disposing of test units, regardless of whether the procedure is approved or rejected, shall be done at no additional cost to the Administration.

When dual bridges are separated by a joint, the two parapets that make up the median barrier shall be constructed in separate operations. Constructing both sections of median barrier simultaneously is prohibited. The first median parapet section shall be allowed to cure for a minimum of 40 hours prior to constructing the second section of median parapet.

Additional reinforcement steel shall be placed to provide bracing for the reinforcement in the parapet to prevent displacement when subjected to the pressure developed in the slip form machine's extruding process. A detail will be included in the Contract Documents. The alignment and rigidity of the reinforcement steel will be strictly enforced by the Engineer to ensure that the minimum clearances shown on the Contract Documents for concrete cover are maintained.

The Contractor shall ensure that a continuous supply of concrete is available at the bridge site during slip forming operations, and that an uninterrupted flow of concrete is provided to the slip form machine. Once the slip form machine is set in motion, it shall keep advancing until it reaches the proposed stopping point. The Contractor shall organize and schedule the operations in a manner that the next concrete truck will be able to move into position at the slip form machine as soon as the previous truck pulls away without interrupting the machine's uniform advancement. Under no circumstances will the Contractor be allowed to operate the slip forming in a manner which requires a concrete truck to be removed from the bridge before another truck can move into place.

Vehicular traffic, except for the slip form machine and its concrete supply trucks, is prohibited on the bridge while slip forming operations are in progress.

When the slip form machine is set up and the sensor wire is placed, a dry run of the equipment shall be made in the presence of the Engineer to ensure that the parapet or median barrier will envelop preset obstacles that are to be embedded or meet with flush surfaces such as pull boxes, expansion joint plates, etc.

The concrete consistency shall maintain the shape of the structure without support after the extrusion. The surface shall be free of surface pits larger than 3/16 in. diameter. The concrete shall require no further finishing, other than light brushing with water only. Finishing with brush applications of grout is prohibited.

If a tear occurs at the top of the parapet or median barrier during the slip forming operation, it shall be repaired immediately. The repair shall be made in a workmanlike manner in conformance with good concrete practices acceptable to the Engineer. The repair shall blend into the barrier to the extent that the naked eye cannot distinguish any difference in the wall face or top.

The rate at which the slip form machine is advanced is crucial to the quality of the finished parapet or median barrier. The Contractor shall ensure that the rate of advancement conforms to the equipment manufacturer's recommended value. The advancement of the slip forming machine on the bridges shall be the same rate as used on the approved test section. A higher or lower rate is prohibited.

The shape of the finished parapet or median barrier shall conform to the dimensions shown on the Contract Documents. The vertical face at the bottom of the concrete safety shaped parapets or median barriers is 3 in. high, and will be unacceptable if this vertical face exceeds 3-1/2 in. The finished parapet or median barrier shall show no deviation from the proposed grade and alignment in excess of 1/4 in./10 ft.

Joints shall be saw cut in the finished parapet or median barrier using a diamond blade. Cuts shall be 1/8 in. wide and 2 in. deep and shall be made in the top, outside and inside faces, stopping 3 in. above the top of deck slab in both faces except where it is impossible for the outside portion of the final placement of back to back median parapets. Joints shall be spaced as shown on the Contract Documents. Reinforcement steel in the parapets and median barriers shall

be terminated at the joint locations. The deck shall be marked to ensure that the saw cuts are made at these locations and do not conflict with the reinforcing steel pattern. The trapezoidal shaped control joints on the outside of parapets will not be required if slip forming is used. Slip form placements shall only be terminated at a parapet control joint. The joints shall be saw cut as soon as possible after initial concrete set and after the concrete has set sufficiently to preclude raveling during the sawing. The sawing shall be completed the same day the concrete is extruded and before any shrinkage cracking has occurred. Concrete shall not be left overnight without saw cutting the joints.

When portions of the bridges are in superelevation with varying rates of slope, the Contractor shall produce the exact configuration of parapets and median barriers as shown on the Contract Documents, i.e., level top surface, wall normal to deck surface, etc.

**(f) Temperature Controls.** Concrete temperatures shall be as specified in 902.10. Concrete below these temperatures shall be heated by one of the following methods:

- (1) When the method of heated mixing water is used, the water shall not be above 170 F when introduced into the mix.
- (2) When the method of heated aggregates is used, aggregates containing frozen lumps shall be independently heated and no materials containing frozen lumps, ice, or snow shall be permitted to enter the mixer. Aggregates may be heated by steam coils or other dry heat but not by discharging live steam or hot water into them. Heating by means of a flamethrower or any direct flame is prohibited.

When the ambient air temperature is below 40 F, the temperature of the air in contact with the reinforcement shall be raised to 40 F prior to placing concrete. When the ambient air temperature is above 70 F and the reinforcement is exposed to the direct rays of the sun, the reinforcement shall be cooled to 70 F or less by means of a water spray prior to placing concrete. When the ambient air temperature is above 70 F and the steel forms that remain in place are exposed to the direct rays of the sun, the forms shall be cooled by means of water spray prior to placing concrete.

When abnormal wind or storms are forecast locally by the National Weather Service, superstructure concrete shall not be placed during the period covered by the forecast.

- (g) **Pumping.** Equipment shall be suitable and adequate in capacity for the work and will be acceptable to the Engineer. The equipment shall be arranged so that no vibrations result which might damage freshly placed concrete. No parts of the pump or discharge line shall be made of aluminum.
- (h) **Use of Conveyors.** Concrete may be moved from the mixer to its final position by use of conveyors. Conveyors shall be in sections and concrete shall be deposited from one conveyor belt onto the next through a hopper. The maximum rise on any individual section of the conveyor is 30 degrees from the horizontal. The maximum belt travel speed shall be 900 ft/minute for concrete slumps less than 2 in. This speed shall be decreased for slumps exceeding 2 in. Conveyors used for placement of decks shall be supported by main load carrying members. Polyethylene or other material acceptable to the Engineer shall be placed under the conveyor line to contain any spillage from the belts onto the deck.

**420.03.05 Depositing Concrete Under Water.** Concrete shall not be deposited in water or exposed to the action of water before setting, unless specified in the Contract Documents or approved by the Engineer in writing. Concrete deposited under water shall be placed by means of a tremie pipe. The tremie pipe shall not be less than 10 in. diameter and shall be equipped with a watertight plug.

The bottom of the pipe shall be equipped with a baffle or deflector plate. The number and location of pipes will be dependent on the size of the pour. After tremie concrete has been placed, it shall not be disturbed nor shall successive layers be placed on top until the previously placed concrete has developed the necessary strength as determined by the Engineer. Concrete shall not be deposited in water where the temperature is less than 35 F. When concrete is deposited in water 36 to 45 F, the concrete shall be heated and placed at a temperature of 60 to 80 F. Pumping of water is prohibited while concrete is being placed. The consistency of the concrete shall be carefully regulated to prevent segregation. Tremie concrete which projects more than 6 in. above the top of the as-planned tremie concrete shall be cut down at no additional cost to the Administration until no portion is more than 6 in. above the as-planned elevation.

- (a) **Cofferdams.** Where cofferdams are used, separate forms shall be constructed within the cofferdams except where footing concrete is to be placed against a base of undisturbed material and where

the cofferdam is to remain in place and act as the concrete form. The water level in the space between form and cofferdam shall be kept below the bottom elevation of concrete for at least 12 hours.

- (b) **Concrete Seals.** When feasible, concrete seals for parts of structures under water shall be placed continuously from start to finish so as to avoid horizontal construction joints. The surface of the concrete shall be kept as nearly horizontal as practicable at all times to ensure thorough bonding. In these cases, each succeeding layer of the seal shall be placed before the preceding layer has taken its initial set. The slump of tremie concrete shall be maintained between 4 and 8 in. and maintained as close to 4 in. as possible. After dewatering and prior to placing any succeeding layers of concrete, the top of the foundation seal (tremie concrete) shall be thoroughly cleaned.
- (c) **Concrete Exposed to Saline Water.** Saline water shall not come in direct contact with the concrete until it has been permitted to harden as required in the following table:

CONCRETE IN SALINE WATER	
SALINE CONTENT OF WATER BY WEIGHT IN PARTS PER THOUSAND	SALINE WATER SHALL NOT CONTACT CONCRETE UNTIL FOLLOWING MINIMUM TIME IN DAYS HAS ELAPSED AFTER INITIAL SET*
0 to 10	0
10+ to 15	7
15+ to 20	14
20+ to 25	21
Over 25	30
* The Engineer may approve a waiver in writing.	

Unless otherwise specified, the concrete shall be wet cured for at least seven days while being maintained at a temperature of 50 F or above.

**420.03.06 Consolidation.** All concrete except concrete deposited under water shall be consolidated by means of internal vibrators unless otherwise directed by the Engineer. These provisions shall also apply to precast members or units.

Vibration shall be applied at points uniformly spaced and not further apart than twice the radius over which the vibration is visibly effective.

- (a) **Internal Vibration.** Internal vibrators shall be of a type and design approved by the Engineer. The intensity of application shall visibly affect a mass of concrete of 1 in. slump over a radius of at least 18 in. and have frequency of vibration not less than 4500 impulses per minute.
- (b) **External Vibration.** External vibrators shall be of a type and design approved by the Engineer. External vibration shall be used as directed by the Engineer for the following sections: very thin, very heavily reinforced, numerous inserts, or where form surfaces are sharply inclined or battered. Filler concrete for steel grid floors shall be consolidated using external vibrators to the steel grid.

**420.03.07 Finishing Concrete Surfaces.** Concrete faces shall be finished with one of the following types. All concrete work shall have an ordinary surface finish as described in (a) below unless otherwise specified.

- (a) **Ordinary Surface.** Immediately following the removal of forms, all fins and irregular projections shall be removed from all surfaces except from those that are not to be exposed or not to be waterproofed. On all surfaces, broken corners or edges and any cavities shall be thoroughly cleaned and, after having been kept moist, shall be carefully pointed and trued with a mortar of cement and fine aggregate mixed in the proportions used in the grade of the concrete being finished. Any excess mortar at the surface of the concrete shall be removed. The mortar patches shall be cured as specified in 420.03.09. Construction and expansion joints in the completed work shall be carefully tooled and cleaned. Joint filler shall be exposed for its full length with clean and true edges. Resulting surfaces shall be true and uniform. Surfaces that cannot be repaired in a manner acceptable to the Engineer shall be completed as special surface finishes.
- (b) **Special Surface.** Fins and projections shall be removed. The surface of the concrete shall then be saturated with water and kept wet for a minimum of two hours. A grout mix of the same proportions as the concrete shall be thoroughly rubbed onto the surface by section using burlap pads or cork floats completely filling all voids, pits, and irregularities. After this grout has dried sufficiently, the excess shall be wiped off with dry, clean burlap. The surface shall then be cured as specified in 420.03.09(f), except that only colorless liquid curing compound shall be used in

this method. The exterior faces of cast-in-place superstructures and end posts for bridges over highways and all interior faces of cast-in-place parapets, bridge median barriers, and end posts shall receive this type of finish. This finish shall not be applied to members that have been constructed by the slip form method.

- (c) **Horizontal Surfaces.** All upper horizontal surfaces such as the tops of parapets, copings, and bridge seats shall be finished by placing an excess of concrete material in the forms and striking off even with a wood template. Tops of handrail (posts and caps), headwalls, parapets, wing walls, and barriers shall be steel troweled to a smooth, dense surface.

The bridge seat bearing areas of the substructure masonry shall be finished to the elevations shown on the Contract Documents. The Contractor shall check the elevation of each bearing area prior to finishing to ensure conformance. Each area shall be checked for level in all directions using a spirit level and adjustments made prior to the setting of the concrete. The area shall be steel troweled to a dense flat surface. Bearing areas that are not flat after final finishing shall be ground to achieve an acceptable surface.

Bearing areas will be rejected whenever the elevation is below that of the surrounding masonry.

- (d) **Bridge Deck Slabs.** Concrete for bridge decks shall be transversely screeded with a power operated cylinder or roller finishing machine approved by the Engineer. The finishing machine and all transverse construction joints shall be set parallel to the nearest support lines (the abutment or pier) on all bridge deck slabs. When the skew angle changes at supports, the screed angle shall be adjusted accordingly as the finishing machine progresses across the deck slab. The concrete shall be placed so that the front edge of the newly placed concrete is as nearly as possible parallel to the skew of the finishing machine. The concrete shall also be placed uniformly ahead of the finishing machine, and shall not be more than 6 in. above the top elevation of the finished deck slab nor more than 10 ft ahead of the finishing machine.

Under no circumstances shall the finishing machine span a length greater than the manufacturer's recommendation. The Contractor may combine machines or use two machines of which both may use a common rail and any additional rail. The proposed method and the location and anchorage of accessories that will remain in the completed superstructures as a result of this requirement shall

be subject to the approval of the Engineer and conform to 420.02.02.

After the concrete has been struck off, the surface shall be checked with a 10 ft straightedge operated in a position parallel to the center line of the structure by means of long handles.

This straightedge shall progress longitudinally in overlapping 5 ft increments and transversely in 2 ft increments to locate any irregularities in the surface. The width of the working face shall not be greater than 2 in. and the straightedge shall be as light weight as possible to avoid distortion of the slab surface.

The concrete surface shall be finished with a full width strip of burlap mechanically or manually dragged across the surface.

- (1) **Slab Grooving.** Grooving shall be performed on all bridge decks including slab bridges, and box culverts built to grade. The grooving operation shall start after the bridge deck slab has been cured in conformance with 420.03.10, and attained a minimum compressive strength specified in 420.03.15. The bridge deck shall be grooved perpendicular to the center line.

The grooves shall be cut using a mechanical saw device that leaves grooves 1/8 in. wide,  $3/16 \pm 1/16$  in. deep, and variably spaced from 5/8 to 7/8 in. apart. The grooves shall extend across the slab to within 1 ft of the gutter lines. The transverse grooving shall not cut across armored joints or any joint in which an existing joint seal may be damaged, but shall stay clear by  $2 \pm 1$  in. on each side. On joints skewed 70 degrees or less, one pass shall be made parallel to the armored joint unless otherwise directed by the Engineer. The residue resulting from grooving operations shall be removed from all surfaces in a manner acceptable to the Engineer. All surfaces shall be left in a washed, clean condition.

- (2) **Deck Slab Tolerances.** Slab thickness shall not be reduced. Any slabs that are found to have deficient thickness may be rejected. The surface shall not deviate in a transverse or longitudinal direction more than 1/8 in./10 ft from a straight line. For vertical curves the deviation (from the curve specified) shall not exceed 1/8 in./10 ft in a longitudinal direction. The corrective work shall be done prior to grooving at no additional cost to the Administration.



- (e) **Sidewalks and Safety Curbs.** The concrete shall be struck off with an approved screed to the elevation and slope specified in the Contract Documents. It shall be wood floated to give a uniformly gritty surface free from depressions or high spots. The joints shall then be edged with the appropriate edging tool. Curbs shall be stripped and finished as soon as possible.
- (f) **Culvert Slabs.** The tops of culvert slabs when they are the roadway riding surface shall be finished in conformance with (d). Invert slabs and the tops of culvert slabs when they are not part of the roadway, or when they are to be overlaid with hot mix asphalt shall be screeded either by hand or machine and have a float finish. The allowable surface tolerance shall be within 1/4 in. of the grade specified in the Contract Documents.

Inverts of culverts having a span less than 10 ft need not be straightedged.

**420.03.08 Curing.** These requirements shall apply to curing of all concrete surfaces except bridge deck slabs or top surfaces of culverts with integral wearing surfaces. Curing for bridge deck slabs and top surfaces of culverts with integral wearing surfaces shall be as specified in 420.03.10.

Curing shall start as soon as the concrete has set sufficiently.

The requirement for keeping the surfaces wet shall be met even in areas where there is no ready water supply.

- (a) Culvert invert slabs and all footings shall be cured for five days using the method specified in 420.03.09(a),(b),(c), or (d).
- (b) Vertical surfaces shall be cured in the forms for seven days. However, the forms may be removed after 24 hours for structural elements 6 ft or less in height, or after 48 hours for structural elements greater than 6 ft high, with the following provisions. The surface shall be cured as specified in 420.03.09(d) for the remainder of the seven day curing period. The forms shall not be removed when cold weather protection is required. Forms, falsework, centering, etc., carrying loads shall remain in place for a minimum of seven days and until the concrete has attained a compressive strength of 3000 psi. Internal bulkheads used for forming construction joints, etc. may be removed after the concrete has been in place for 24 hours if it is necessary to do so to continue the work without interruption. When a higher strength concrete than specified is used, forms, falsework, centering, etc., carrying loads shall remain in place for three and a

half days and until the concrete has attained a compressive strength of 3000 psi.

Fiber column forms may be removed at times specified above, but no later than 10 days after placing concrete.

When parapets or median barriers on structures are formed by the slip form method, curing shall begin as specified in 420.03.09(f) using a fugitive dye liquid membrane-forming compound immediately after the concrete is finished. Immediately after each joint is saw cut, the concrete surfaces shall be cured for the remainder of the seven days of cure as specified in 420.03.09(d).

- (c) Tops of end walls, end support walls, headwalls, etc., shall be cured for three days with burlap or cotton mats as specified in 420.03.09(b) or (d), respectively.
- (d) Horizontal surfaces shall be cured for seven days as specified in 420.03.09 using method (b),(c),(d), or (e).

#### 420.03.09 Curing Methods.

- (a) **Flooding.** Units of structures that will be below water in the completed structure, i.e., bottom slabs of culverts, footings, struts, etc., may be gradually flooded when approved by the Engineer after the concrete is 12 hours old, provided the curing water conforms to 921.01. The temperature of this water shall be maintained at 35 F or above for the specified curing time.
- (b) **Burlap.** Two layers of burlap shall be used. Successive strips of burlap shall be overlapped a minimum of 6 in. The second burlap layer shall be placed not less than 45 degrees to the first layer, or in lieu of this, the 6 in. overlap of the second layer may be placed midway between the first layer. This material shall be thoroughly saturated by immersion in curing water for at least 24 hours prior to placement and shall be kept saturated throughout the time specified for curing.
- (c) **White Opaque Polyethylene Backed Nonwoven Fabric.** One layer of white opaque polyethylene backed fabric shall be used. Successive strips shall be overlapped a minimum of 6 in. This material shall be thoroughly saturated by immersion in curing water for at least 24 hours prior to placement and shall be kept saturated throughout the time specified for curing.
- (d) **Cotton Mats.** One layer of cotton mat material shall be used and shall be kept thoroughly saturated with curing water prior to

placement and throughout the time specified for curing. The material shall be kept in tight contact with the concrete.

- (e) **White Opaque Burlap Polyethylene or White Opaque Polyethylene Film.** The white opaque burlap polyethylene sheeting shall be placed on no less than one layer of wet burlap with the burlap side of the sheeting facing down. White opaque polyethylene film, if used, shall be placed on no less than two layers of wet burlap. Only one layer of cotton mats is required in any usage. These materials may only be used atop the wet burlap or cotton mats on unobstructed flat and reasonably level surfaces.

Adjacent mats or sheets shall be lapped no less than 1 ft. The ends shall be brought down around the sides of the concrete being cured and securely fastened to make an airtight seal.

The white opaque burlap polyethylene sheeting or the white opaque polyethylene film shall remain in place for the same length of time as required for burlap or cotton mats. These protective coverings need not be wetted down, however, the covered burlap or cotton mats shall be kept wet for the time interval specified.

- (f) **Liquid Membrane.** Liquid membrane forming compound shall be applied in conformance with manufacturer's recommendation or as directed by the Engineer. The material shall be applied by sprayers and shall be thoroughly agitated before and during use.

**420.03.10 Bridge Deck Slabs.** Bridge deck slabs and culvert top slabs with integral wearing surfaces, including sidewalks, shall be cured as follows:

The Contractor shall have misting equipment available. Prior to placement of any concrete, operation of the misting equipment shall be verified by the Engineer to ensure that the equipment and procedure are capable of misting the entire placement area without damaging the fresh concrete. This shall be done at the location of proposed use each day that a deck placement is to be made. Ample spare parts, water, fuel, etc. shall be readily available. A backup tested unit shall also be available.

The Contractor shall cover the finished concrete with wet burlap as specified in 420.03.09(b). The concrete covering shall progress immediately after the concrete has been finished but no portion of the concrete shall remain uncovered for more than 45 minutes after placement. Mist spraying shall be used when directed by the Engineer, and when the concrete is not covered with wet burlap within 30 minutes

after placement. Once misting is started, it shall continue until wet burlap is complete in place.

Use of the mist spray shall not relieve the Contractor of the responsibility for covering the concrete within the 45 minutes after placement.

After the concrete is covered with wet burlap, it shall be cured in conformance with 420.03.09(b) for the remainder of the seven day period. The two layers of burlap shall be kept continuously and uniformly saturated throughout the curing period. White opaque burlap polyethylene sheeting and white opaque polyethylene film or clear polyethylene film shall not be placed over wet burlap except when approved by the Engineer in writing for cold weather protection. A sufficient quantity of soaker hoses shall be used to conform to these requirements. The Contractor shall take immediate action to remedy improper saturation of any area throughout the entire curing period.

The Contractor shall provide a sufficient number of experienced personnel and necessary equipment to ensure proper placement, protection and curing of the concrete in conformance with these Specifications.

The Contractor shall also provide temporary troughs, dams, etc., necessary to prohibit the runoff water from reaching any traveled roadway, shoulder or sidewalk. The proposed methods of controlling runoff water in these areas shall be submitted to the Engineer for approval before use. The plan shall include locations of all troughs and dams, as well as the proposed methods of attaching them to any portions of the structure. There shall be no welding or drilling holes in any portion of a permanent member of the structure.

After the procedure is underway, it shall be evaluated, and any areas not functioning in a manner acceptable to the Engineer shall be modified by the Contractor to satisfy the requirements for retaining and directing the flow of water.

In rehabilitation construction, where the full use of temporary troughs, dams, etc., is not practical, modifications to the provisions for controlling the runoff water shall be made by the Contractor and approved by the Engineer.

**420.03.11 Construction Joints.** Construction joints shall be kept to a minimum and will be permitted only where specified in the Contract Documents, or authorized by the Engineer in writing.

The surface of the hardened concrete shall be cleaned and kept moistened until the additional concrete is placed. The top surface of concrete shall be leveled using a grade strip, unless otherwise specified. At chamfers the top surface of the concrete shall be steel troweled adjacent to the chamfer using the top surface for the chamfer strip as a guide.

Where a featheredge might be produced at a construction joint, as in the sloped top surface of a wing wall, an inset form shall be used to produce a blocked in addition to the preceding placement. The inset form shall produce a 6 in. minimum edge thickness of concrete in the succeeding placement.

The Contractor shall place an epoxy bonding compound on the surface areas of existing concrete (concrete that existed prior to the beginning of the Contract) which will be in contact with new concrete. Epoxy bonding compound shall also be applied to the entire face of all bridge deck slab construction joints. The surfaces to be coated shall be clean, sound, and dry and bonding compound shall be mixed and applied in conformance with the manufacturer's recommendations.

**420.03.12 Linseed Oil Protective Coating.** Linseed oil protective coating shall be applied to the integral concrete bridge deck slabs, box culvert wearing surfaces and sidewalks on bridges and box culverts when the pertinent Linseed Oil Protective Coating item appears in the Contract Documents.

Permanent paint or tape lane markings required on the structures shall be placed prior to the application of the linseed oil protective coating. The concrete surfaces to be treated shall also be cured, dried and thoroughly cleaned of all dust, dirt, and deleterious material prior to placing the first linseed oil protective coating.

If the concrete is wet, it shall be allowed to dry for one to two days at a minimum temperature of 60 F. If the concrete surfaces are extremely dry, the Contractor shall either wet the concrete thoroughly and allow it to dry for one or two days or apply a third protective coating at the same rate per gallon as the second coat, as directed by the Engineer. The ambient temperature at the time of application shall be 50 F minimum. Following the second application, the ambient temperature shall be 40 F minimum. Two coats shall be applied on all top surfaces that are not grooved. The first coat shall be applied at a rate of 40 yd<sup>2</sup>/gal. The second coat shall be applied at a rate of 67 yd<sup>2</sup>/gal. On bridge decks and top slabs of box culverts that are grooved, the first coat shall be applied at a rate of 25 yd<sup>2</sup>/gal. The second coat shall be applied at a rate of 45 yd<sup>2</sup>/gal. The second coat shall not be applied until the first coat is dry. If additional coats are required, there shall be a minimum of 24 hours between them.

The drying time may be increased as the ambient temperature falls below 70 F.

**420.03.13 Cold Weather Protection.** Concrete shall be protected and heated after it has been placed when the air temperature in the shade and away from artificial heat drops to 40 F or lower at the time of placing or at any time within the number of days specified herein. Protection and heating shall be as follows:

- (a) Ordinary concrete shall be protected and kept continuously at a temperature not less than 50 F for at least seven days following placement.
- (b) In no case shall concrete be heated to more than 100 F. At the end of the heating period, the concrete surfaces shall be cooled to the temperature of the outside air by slowly reducing the artificial heat at a uniform rate until the temperature of the outside air is reached within a 24 hour period.

The Contractor shall have tarpaulins, insulating devices, and other suitable materials at the site to enclose or protect all portions of the concrete requiring protection. Materials shall be installed as close as possible before placing the concrete, and it shall be installed as rapidly as possible to keep exposure to cold weather to a minimum. Where heating is required, the spaces to be heated shall be completely enclosed and the temperature kept at required levels by the use of heaters approved by the Engineer.

The Contractor shall provide a sufficient number of maximum/minimum recording thermometers to record temperatures in each concrete placement undergoing cold weather protection.

The curing period for all structure concrete requiring cold weather protection shall conform to the cold weather protection period except when the normal curing period is longer.

**420.03.14 Underpinning Old Foundations.** If underpinning is required, the Contractor shall perform the required work as directed by the Engineer. The operation shall consist of the restoring or lowering of the old foundations with concrete. The concrete shall be Mix No. 6. Excavation and the underpinning operations shall be done in part section, so as not to remove more than 10 percent of the supporting area under the old foundation at one time. The concrete shall have a maximum slump of 1-1/2 in. When directed by the Engineer, underpinning shall be installed by hand, pneumatic, or pumping processes. The usual curing and cold weather requirements will be deleted for the underpinning with other

provisions for curing and protection improvised on the job as may be directed.

**420.03.15 Loads on Concrete Structures.** The erection of structural steel or concrete superstructures on concrete substructures shall not start until the Contractor has completed curing, removed forms, and substructure concrete has reached a minimum compressive strength of 3000 psi.

Loads shall not be applied to any new portion of bridge deck or box culvert built to grade until the final section of that unit of the deck has completed its specified curing period. Vehicles, including the Contractor's, and heavy equipment are not permitted on any new portion of bridge deck or box culvert built to grade until the concrete cylinder breaks for the final section of that unit of the deck has attained a minimum compressive strength of 4500 psi. However, loads such as stored materials, lightweight equipment, concrete safety parapets, sidewalks, median curbs, etc., may be placed upon the concrete slab via cranes or other lifting devices when the concrete in the final section of that unit of the deck has attained a minimum compressive strength of 3000 psi.

Backfill shall not be place on any new portion of box culverts not built to grade until the final section of that unit of the slab has completed its specified curing period and the concrete in that section has attained a minimum compressive strength of 3000 psi.

**420.03.16 Prevention and Removal of Stains on Concrete.** The Contractor shall prevent rust from structural steel, staining by asphalt materials or any other substance from discoloring any portion of the concrete. The Contractor shall use construction procedures that prevent staining of any of the concrete. Where unpainted structural steel has been specified, the Contractor shall protect the pier caps, columns and abutments with a wrapping of reinforced polyethylene or similar material which shall be left in place to prevent staining until after the structure has been completed. If any portion of the concrete is stained, the stains shall be removed and concrete restored to its original color without damage to the concrete. The work shall be done as directed by the Engineer at no additional cost to the Administration. Chemical solvents shall not be used to remove stains unless approved by the Engineer.

**420.03.17 Safety Hazards.** The Contractor shall be responsible for gas detection in and ventilation of confined spaces as specified in TC-3.05.

**420.03.18 Defective Work.** Defective work exposed upon removal of the forms shall be entirely removed or repaired within 24 hours, as directed by the Engineer.

- (a) Edges of material remaining in place shall be cut perpendicular to the finished surface to the full depth of the material removed, but not less than 1 in. If the removal of defective concrete affects the structural requirements, the member also shall be removed and replaced as directed by the Engineer.
- (b) Defective areas shall be cleaned.
- (c) Defective areas shall be coated with an epoxy bonding compound.
- (d) Defective areas shall be patched with concrete mortar or epoxy. The color, contour, and texture of surrounding concrete shall be matched as close as possible.

**420.04 MEASUREMENT AND PAYMENT.** Portland cement concrete structures will be measured and paid for as specified. The payment will be full compensation for all forms and form removal, reinforcement steel, curing and misting, scuppers, grooving, mechanical and electrical work, all cost incidental to the conducting of tests for oxygen content and presence of gases and applying mechanical ventilation to confined spaces, year built markings, and all material, labor, equipment (including safety equipment), tools and incidentals necessary to complete the work.

The construction of drainage and weep holes, any pipe necessary, expansion material, flashing, dampproofing, membrane waterproofing, epoxy bonding compound, joints and their placement will not be measured but the cost will be incidental to the concrete item. No deduction in concrete quantities will be made for pipes or conduits having diameters less than 8 in., reinforcement steel, anchors, or any other appurtenances.

**420.04.01** Portland cement concrete for Footing Concrete, Subfoundation Concrete and Tremie Concrete will be measured and paid for at the Contract unit price per cubic yard.

**420.04.02** Portland cement concrete for Substructure Concrete for Bridge, Superstructure Concrete for Bridge, and Reinforced Concrete Box Culverts will not be measured but will be paid for at the Contract lump sum price. The cost for epoxy protective coated reinforcement steel shall be excluded from the Contract lump sum price for Superstructure Concrete for Bridge. When a bridge deck rehabilitation project, other than bridge widenings, requires modification to the backwalls and wing walls and there is no substructure concrete item, the concrete will be incidental to the Superstructure Concrete item.



**420.04.03** Wing walls and footings for reinforced concrete box culverts will not be measured but the cost will be incidental to the Reinforced Concrete Box Culvert item.

**420.04.04** Parapets (including end posts) on bridges, wing walls, reinforced concrete box culverts and retaining walls, or concrete median barriers on bridges and top slabs of reinforced concrete box culverts will not be measured but will be paid for at the Contract lump sum price for the pertinent Concrete Parapet or Concrete Median Barrier items.

**420.04.05** Parapet and end post modifications on bridges, wing walls, reinforced concrete box culverts and retaining walls, or concrete median barriers on bridges and top slabs of reinforced concrete box culverts will not be measured but will be paid for at the Contract lump sum price for the pertinent Parapet Modification item. The payment will also include saw cutting, removal of portions of the existing parapet or end post, drilling, and grouting.

**420.04.06** Floodlighting will be measured and paid for at the Contract unit price per each night used, including fuel, backup generator, setup, relocation, and removal.

**420.04.07** Linseed oil protective coating will be measured and paid for at the Contract unit price per square yard for the pertinent Linseed Oil Protective Coating item.

**420.04.08** Temporary supports or piling will not be measured but the cost will be incidental to the formwork.

**420.04.09** Retaining walls will be measured and paid for as specified in 450.04

## SECTION 421 — REINFORCEMENT FOR CONCRETE STRUCTURES

**421.01 DESCRIPTION.** This work shall consist of furnishing and placing reinforcement, including deformed steel bars, wire mesh, and plain round steel spiral bars, as specified in the Contract Documents or as directed by the Engineer. Reinforcement shall be uncoated or epoxy coated as specified in the Contract Documents.

### 421.02 MATERIALS.

Grout	902.11(c)
Deformed Steel Bars	908.01